High-Angular-Momentum Structures in ^{64}Zn

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The recent observation of rotational bands in the proton-rich nuclei near A=60 are of considerable current interest. The limited number of valence particles outside of the spherical doubly magic nucleus ^{56}Ni means that the low-angular-momentum decay schemes are dominated by spherical shell-model states. At higher angular momentum collective bands dominate. Such bands provide an important testing ground of nuclear models since the limited number of valence nucleons enable comparisons between mean-field cranking models, traditionally used to describe collective behavior in heavier nuclei, and large-scale shell-model calculations. The first rotational structure identified in this region was a strongly coupled band assigned to ^{64}Zn [1]. The characteristics of this band were very similar to those of smoothly terminating rotational bands in the Sn-Sb nuclei of the A=110 region [2]. Such terminating bands are expected in the A=60 region since the maximum spin available from possible configurations is limited to I=20-30 h.

We performed an experiment to investigate collective structures in ^{64}Zn. High-angular-momentum states were populated in the ^{40}Ca(^{28}Si,4p) reaction at a beam energy of 122 MeV. Gamma rays were detected with the Gammasphere array. Light, charged particles were detected with the Microball, an array of 95 CsI(Tl) scintillators. Hevimet collimators were removed from the BGO suppressors to enable gamma-ray sum energy and multiplicity measurements. A total of 2.3×10^9 coincidence events, with at least four Compton suppressed gamma rays, were collected. The ^{64}Zn channel was one of the most strongly populated channels, produced in approximately 15% of the fusion-evaporation events.

The level scheme of this nucleus was considerably revised and extended. In addition to the known strongly coupled band a new strongly coupled collective structure was observed. Both structures have been firmly linked to low-lying states establishing spins, parities, and excitation energies for the first time. Comparisons of the structures with cranked Nilsson-Strutinsky calculations suggest single-particle configurations involving proton excitations across the Z=28 spherical shell gap from the $f_{7/2}$ to the $g_{9/2}$ orbital, coupled with neutron excitations involving the $g_{9/2}$ orbital. It also seems that we are seeing both structures up to their fully aligned terminating states. One unusual feature, currently not understood, is the observation of strong gamma decay branches from the higher lying strongly coupled band to the lower one.

References

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